CHAPTER IV

DETERMINATIONS AND MEASUREMENTS PRIOR TO SAMPLING

TECHNICAL SUPPORT SERVICES
APPLIED SCIENCE AND TECHNOLOGY
MARCH 1989

Velocity and Sample Traverse Points

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

METHOD 1.1

SAMPLE AND VELOCITY TRAVERSES FOR STATIONARY SOURCES

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Section 1 of 2

1. Overview

1.1 Principle

To make a representative measurement of pollutant emissions and/or total volumetric flow rate from a stationary source, select a measurement site where the effluent stream flows in a known direction and divide the cross section of the stack into a number of equal areas. Then locate a traverse point at the centroid of each of these equal areas.

1.2 Applicability

This method applies to flowing gas streams in ducts, stacks, and flues. The method cannot be used when (1) flow is cyclonic or swirling (see Section 2.4), (2) a stack is smaller than about 0.30 meter (12 in.) in diameter or 0.071 m^2 (113 in.^{2}) in cross sectional area, or (3) the measurement site is less than two stack or duct diameters downstream or less than one-half diameter upstream from a flow disturbance (see Chapter X, section on Alternative Site Selection Method).

See Chapter X for non-standard conditions when flow is cyclonic or non-parallel. See Method 2.2 when a stack diameter is smaller than about 0.3 m (12 in.).

The requirements of this method should be considered before construction of a new facility from which emissions will be measured. Failure to do so could result in alterations to a stack or deviation from the standard procedure. Variations from the requirements of this method are subject to approval by the Executive Officer.

2. Field Procedures

2.1 Selection of Measurement Site

Sampling or velocity measurement is performed at a site located at least eight stack or duct diameters downstream and two diameters upstream from a flow disturbance (such as a bend, expansion, or contraction in the stack), visible flame, chemical injection, or chemical reaction.

If necessary, select an alternative location at a position at least two stack or duct diameters downstream and one-half diameter upstream from any flow disturbance. To determine upstream and downstream disturbances for a rectangular cross section, calculate an equivalent diameter as follows:

$$\text{Equivalent Diameter} = \frac{2 \times \text{Length} \times \text{Width}}{\text{Length} + \text{Width}}$$

2.2 Determination of Number of Traverse Points

2.2.1 Particulate Traverse

When the eight and two diameter criterion can be met, the minimum number of traverse points shall be (1) twelve, for circular or rectangular stacks with diameters (or equivalent diameters) greater than 0.61 m (24 in.), and (2) eight, for circular stacks with diameters between 0.30 and 0.61 m (12-24 in.).

When the eight and two diameter criterion cannot be met, the minimum number of traverse points is determined from Figure 1.1-1. Before referring to Figure 1.1-1 determine the distances from the chosen measurement site to the nearest upstream and downstream disturbances. Then divide each distance by the stack diameter or equivalent diameter to determine the distance in terms of the number of duct diameters. Determine from Figure 1.1-1 the minimum number of traverse points that corresponds (1) to the number of diameters upstream, and (2) to the number of diameters downstream.

Select the higher of the two minimum numbers of traverse points, or a greater value, so that for circular stacks the number is a multiple of 4, and for rectangular stacks the number is one of those shown in Table 1.1-1.

2.2.2 Velocity (Non-Particulate) Traverses

To measure velocity or volumetric flow rate (but not particulate matter), follow the same procedure as for particulate traverses (Section 2.2.1) except that Figure 1.1-2 may be used instead of Figure 1.1-1.

2.3 Cross Sectional Layout and Location of Traverse Point

2.3.1 Circular Stacks

Locate the traverse points on two perpendicular diameters according to Table 2 and the example shown in Figure 1.1-3. Any equation that gives the same values as those in Table 2 may be used. For particulate traverses, one of the diameters must be in a plane containing the greatest expected concentration variation, e.g. after bends, one diameter should be in the plane of the bend. This requirement becomes less critical as the distance from the disturbance increases. Therefore, when the disturbance is 4 diameters upstream or 1 diameter downstream, other diameter locations may be used.

For stacks with diameters greater than 61 cm (24 in.), no traverse points shall be located within 2.5 cm (1.00 in.) of the stack walls. For stack diameters equal to or less than 61 cm (24 in.) no traverse points shall be located within 1.3 cm (0.50 in.) of the stack walls. To meet these criteria, use the following the procedures:

2.3.1.1 Stacks with Diameters Greater than 61 cm (24 in.)

When any of the traverse points as located in Section 2.3.1 fall within 2.5 cm (1.00 in.) of the stack walls, relocate them away from the stack walls to (1) a distance of 2.5 cm (1.00 in.), or (2) a distance equal to the nozzle inside diameter, whichever is greater. These relocated traverse points (on each end of a diameter) are the "adjusted" traverse points.

Whenever two successive traverse points are combined to form a single adjusted traverse point, treat the adjusted point as two separate traverse points, both in the sampling (or velocity measurement) procedure, and in recording data.

2.3.1.2 Stacks with Diameters Equal to or Less Than 61 cm (24 in.)

Follow the procedure in Section 2.3.1.1 noting only that any "adjusted" points should be relocated away from the stack walls to (1) a distance of 1.3 cm (0.50 in.), or (2) a distance equal to the nozzle inside diameter, whichever is greater.

2.3.2 Rectangular Stacks

Determine the number of traverse points as explained in Section 2.1 and 2.2 of this method. From Table 1.1-1, determine the grid configuration. Divide the stack cross section into as many equal rectangular elemental areas as traverse points. Then locate a traverse point at the centroid of each equal area according to the example in Figure 1.1-4.

To use more than the minimum number of traverse points, expand the "minimum number of traverse points" matrix (see Table 1.1-1) by adding extra traverse points along one or both legs of the matrix. The final matrix does not have to be balanced. For example, if a 4 x 3 "minimum number of traverse points" matrix were expanded to 36 points, the final matrix could be 9 x 4 or 12 x 3, keeping the minimum grid of 3, and would not have to be 6 x 6.

After constructing the final matrix, divide the stack cross section into as many equal rectangular elemental areas as traverse points, and locate a traverse point at the centroid of each equal area.

Locating traverse points too close to the stack walls is not expected to occur with rectangular stacks. If this problem should arise, it must be resolved by an authorized representative of the Executive Officer.

2.4 Verification of Absence of Cyclonic Flow

In most stationary sources, the direction of stack gas flow is essentially parallel to the stack walls. However, cyclonic flow may exist (1) downstream of devices such as cyclones and inertial demisters following venturi scrubbers, or (2) in stacks having tangential inlets or other duct configurations which tend to induce swirling. In these instances, the presence or absence of cyclonic flow at the sampling location must be determined. The following technique is acceptable:

Level and zero the manometer or the magnehelic gauge. Connect an S-type Pitot tube to the manometer or magnehelic gauge. Position the Pitot tube at each traverse point, in succession, so that the planes of the face openings of the Pitot tube are perpendicular to the stack cross sectional plane. When the Pitot tube is in this position it is "0^{o} reference".

Note the differential pressure reading at each traverse point. If a null (zero) Pitot reading is obtained at 0^{o} reference at a given traverse point, an acceptable flow condition exists at that point. If the Pitot reading is not zero at 0^{o} reference, rotate the Pitot tube (up to $\pm$ 90^{o} yaw angle) until a null reading is obtained.

Carefully determine and record the value of the rotation angle (a) to the nearest degree.

After the null technique has been applied at each traverse point, calculate the average of the absolute values of (a), assign a value of 0^{o} to those points for which no rotation was required, and include these in the overall average. Record the data in a form as shown in Figure 1.1-5.

Flow in rectangular ducts can be especially deceiving. Measuring sites with yaw angles above 30^{o} at more than four traverse points or reverse flow at any traverse point are not acceptable. Measure the angles from ports perpendicular to the plane with the maximum flow variation unless a directional flow sensing probe is used (see

Chapter X, section on Alternative Site Selection Method).

If the average of the absolute values of (a) is greater than 10°, the overall flow condition in the stack is unacceptable (see Chapter X for non-standard conditions).

Table 1.1-1

Cross Sectional Layout for Rectangular Stacks

Number of Traverse Points	Matrix Layout
9	3 x 3
12	4 x 3
16	4 x 4
20	5 x 4
25	5 x 5
30	6 x 5
36	6 x 6
42	7 x 6
49	7 x 7

Table 1.1-2

LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS

(Percent of stack diameter from inside wall to traverse point)

Traverse point number on a diameter	Number of traverse points on a diameter											
	2	4	6	8	10	12	14	16	18	20	22	24
1	14.6	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	85.4	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3		75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4		93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5			85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6			95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7				89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8				96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9					91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10					97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11						93.3	85.4	78.0	70.4	61.2	39.3	32.3
12						97.9	90.1	83.1	76.4	69.4	60.7	39.8
13							94.3	87.5	81.2	75.0	68.5	60.2
14							98.2	91.5	85.4	79.6	73.8	67.7
15								95.1	89.1	83.5	78.2	72.8
16								98.4	92.5	87.1	82.0	77.0
17									95.6	90.3	85.4	80.6
18									98.6	93.3	88.4	83.9
19										96.1	91.3	86.8
20										98.7	94.0	89.5
21											96.5	92.1
22											98.9	94.5
23												96.8
24												98.9

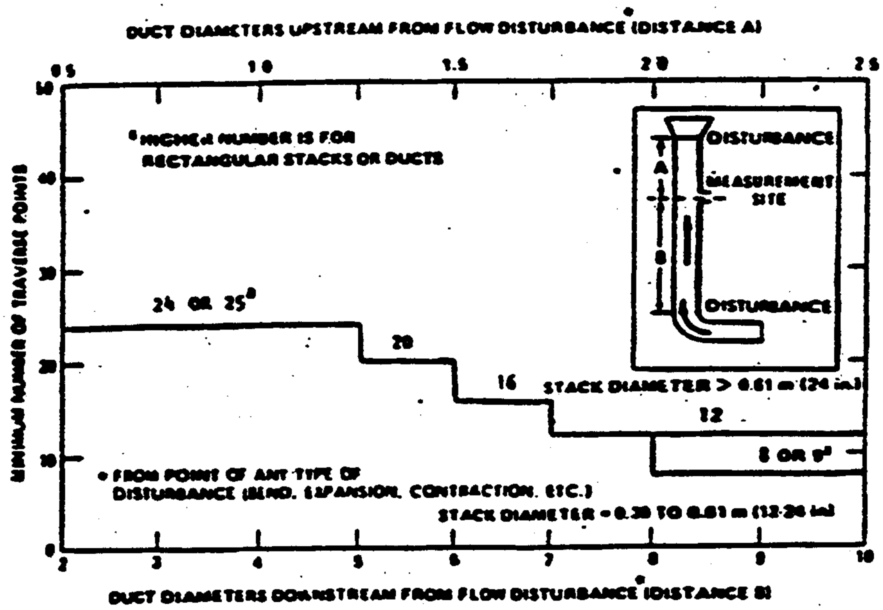

Figure 1.1-1

Minimum Number of Traverse Points for Particulate Traverses

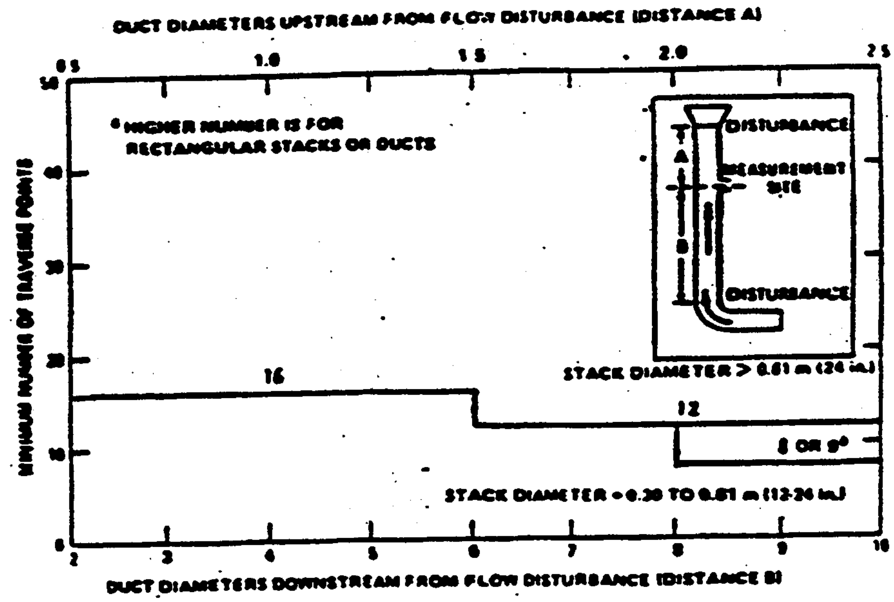

Figure 1.1-2

Minimum Number of Traverse Points for Velocity (Nonparticulate) Traverses.

TRAVERSE POINT	DISTANCE, % of diameter
1	4.4
2	14.7
3	29.5
4	70.5
5	85.3
6	95.6

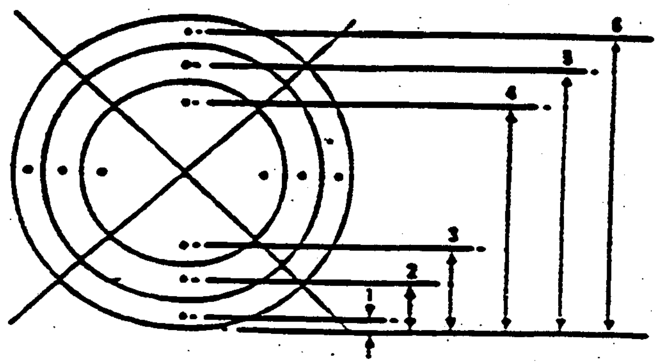

Figure 1.1-3

Example Showing Circular Stack Cross Section Divided into 12 Equal Areas, with Location of Traverse Points Indicated

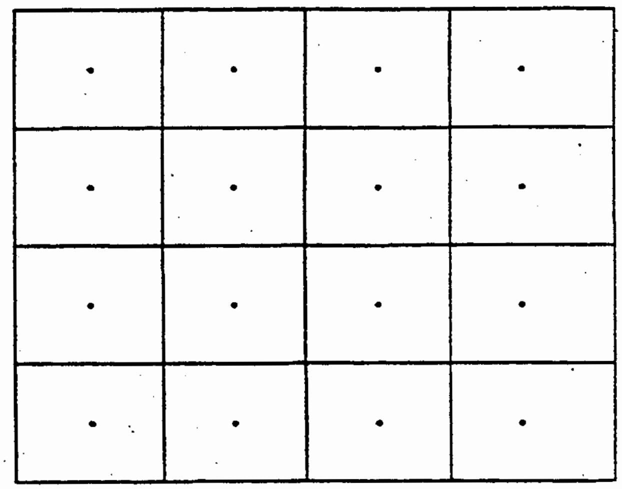

Figure 1.1-4

Example Showing Stack Cross Section Divided into Sixteen Equal Areas, with a Traverse Point at Centroid of Each Area

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No.____________ Date________________

Sampling Location____

DATA SHEET FOR VERIFICATION OF CYCLONIC FLOW

Pretest Velocity Leak Check__________________
Post Test Velocity Leak Check________________

Time	Traverse Point	ΔP (in. H_2O) at 0^o Reference	Null Point Rotation Angle ($\pm \alpha$)	Comments

Recorded By_______________

Average (Absolute Values of α)______________

Calibration Data

Inclined Manometer______(Cal: N/A)
Magnehelic No.__________(Cal:______)
Pitot Tube No.__________(Cal:______)

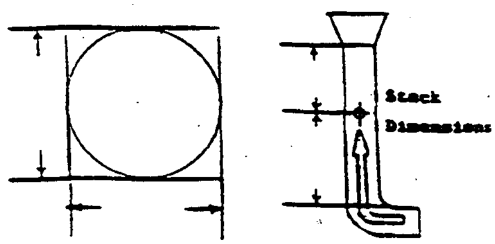

Figure 1.1-5

Data Sheet for Verification of Cyclonic Flow